Low-volume Air-blast Spraying

in British Columbia Orchards 1957—1962

CANADA DEPARTMENT OF AGRICULTURE PUBLICATION 1191 1963

NEW DEVELOPMENTS IN LOW-VOLUME ORCHARD SPRAYERS

In British Columbia the machines and methods used in low-volume spraying have undergone important changes since 1957. But the essential feature of the technique remains: **there is no spray drip.**

Many of the earlier sprayers were built without enough knowledge of the low-volume technique. They have proved inadequate, largely because they do not apply enough pesticide to the tops of large trees, and tend to overspray the lower branches. The main new developments are:

- Sprayers with power-take-off drive are replacing engine-powered machines.
- Small, but efficient, squirrel-cage fans are replacing axial-flow fans and paddle-type centrifugal fans.
- Air velocity is being increased from 110 miles per hour, or less, to 130 or 140 miles per hour. Air volume (output) remains about 8,000 cubic feet per minute per side.
- Diaphragm pumps are largely replacing high-pressure piston pumps. They are rugged, simple, easily repaired and low in cost.
- Liquid pressure is being decreased from about 300 pounds per square inch to 100 pounds.
- The best of the new machines apply 50 imperial gallons of spray liquid per acre.
- A special type of surfactant is recommended to improve the uniformity of deposits of wettable powders.

You should not buy a low-volume sprayer as casually as you buy an automobile. When you buy an automobile you usually get just about what you pay for; when you buy a sprayer you may not be so fortunate. And a poor sprayer, and poor crops, go hand in hand.

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Low-volume Air-blast Spraying in British Columbia Orchards 1957–1962

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This publication summarizes the developments in low-volume spraying in British Columbia since 1957. It deals with the characteristics of the latest type of low-volume air-blast sprayer, and tells how the machine should be operated.

Several years ago a publication of the Canada Department of Agriculture reviewed the development of concentrate spraying from its beginnings up to the year 1957 (3). Since then the technique has been more and more widely applied. Low-volume spraying, or concentrate spraying as it is commonly known in British Columbia, is now practised in every major deciduous fruit-growing area of the world.

Whether or not there is spray drip is the most significant feature of orchard spraying. In high-volume spraying there is drip; in true low-volume spraying there is no drip. If drip should occur in low-volume spraying it indicates either faulty equipment or careless operation (3).

Low-volume spraying requires greater care than high-volume spraying. That point is not always given the attention it merits. As a result, the control of pests and diseases in British Columbia orchards, although better than in the days of high-volume spraying, is by no means as good as it might be. When low-volume machines are operated carelessly the bottoms of the trees are often oversprayed and the tops of the trees undersprayed.

Ever since low-volume orchard spraying became general in British Columbia, some of the more conservative have tended to attribute all manner of orchard ills to the new technique. Anjou pear trees develop blackened foliage. "It's concentrate spray injury." There is an outbreak of the McDaniel mite. "We are not using enough spray." The San Jose scale reappears. "The trees should be soaked—better go back to the spray gun." And so it goes.

The simplest way to explain such troubles is to attribute them to the method of spraying. But, in fact, there is nothing wrong with the method. It is one of the most logical developments in the history of fruit growing. Since the adoption of low-volume spraying in this province, every

[1]Contribution No. B8, Research Station, Summerland.

instance of faulty pest control that has been critically looked into has been found to be due not to the technique itself but to errors in applying it.

Four years of research and development preceded the recommendation of low-volume spraying to British Columbia fruit growers in 1949. The specifications for the new equipment were clear enough. But in the rush to buy new machines, or to convert old high-pressure machines into "automatic" sprayers, many fruit growers equipped themselves with cheap, hybrid devices that fell short of requirements.

Scores of these inferior machines are still in operation. Two circumstances have enabled them to persist. First, until resistance to them develops, modern pesticides are so effective that even inadequate application may suffice. Second, until recently, recommended spray dosages were higher than necessary because faulty application was presupposed. Soon after the recommended pesticide dosages were reduced to the levels found adequate with efficient application, reports of poor pest control became more common. The insects and the mites began to sort out the good spray equipment from the bad, and the careful spray operator from the careless.

Poor pest control nowadays may indicate that the pest has developed resistance to the pesticide, or that spray application is faulty. In the first case another pesticide must be used. In the second the dosage must be increased, or the machine must be operated with more care, or it must be replaced by a better one.

The district horticulturists of the British Columbia Department of Agriculture have the special equipment and knowledge for assessing low-volume sprayers. They should be consulted if sprayer trouble is suspected.

REQUIREMENTS IN A LOW-VOLUME ORCHARD SPRAYER

Volume of Spray Liquid per Acre

A great deal of research, involving both chemical and biological assessments, has led to the adoption of a standard spray output for British Columbia orchards. It is 50 imperial gallons per acre for mature trees (8). More liquid means a heavier machine, needless loss of time in refilling, and the possibility of spray drip and hence spray injury. Less liquid means the possibility of spray drift and also of excessive evaporation of fine spray droplets in hot, dry weather. With equipment that applies only 50 gallons per acre the tank need not be large. A capacity of 150 to 200 gallons is adequate. To spray three or four acres at a filling is a satisfying accomplishment, particularly to those who recall the day of high-volume application with its two to

four tankfuls per acre.

Weight of Machine

Since horticulturists are uneasy about soil compaction, one of the desirable characteristics of a sprayer is lightness. A single-side low-volume sprayer weighs between 1,000 and 1,500 pounds empty, depending on whether it is equipped with a power-take-off drive or an engine. On the same basis, a two-side unit weighs between 1,200 and 2,000 pounds empty.

Air Volume and Air Velocity

Investigators in some areas claim that in spraying it is necessary to replace all the air within the tree. They believe that volume of the air is much more important than the velocity. Others claim that air velocity is much more important than volume. In British Columbia, air volume and air velocity are both considered important. It has been found that, for low-volume spraying of mature, standard apple trees in rows 30 feet apart, the sprayer should produce an airstream with an average velocity of at least 100 miles per hour, and a volume of at least 7,000 cubic feet per minute per side. A sprayer like this usually gives adequate tree-top deposits of pesticide without overspraying the lower limbs. A sprayer with an airstream averaging 140 miles per hour and 8,000 cubic feet per minute gives improved distribution, with tree-top deposits slightly higher and tree-bottom deposits slightly lower. Sprayers with an airstream averaging much less than 100 miles per hour, regardless of air volume, tend to overspray the parts of the trees close to the air vent; sprayers with an air volume much less than 7,000 cubic feet per minute per side usually do not get enough pesticide to the tops of mature trees, regardless of air velocity.

Sprayers of the type described here cannot be expected to do a good job when there is a wind. Much higher air volume is required then.

The Fan

Since low-volume spraying requires a high-velocity air blast, the type of fan (which is really the heart of the sprayer) is of great importance. In the last 16 years fans of many kinds have been tested at the Research Station at Summerland. Many have been fair; some have been poor; few have been good. The most efficient is a centrifugal fan of the squirrel-cage type (7). Many fans produce an airstream with a maximum velocity below the desired 130 or 140 miles per hour. The squirrel-cage fan readily generates velocities in this range if the blades are kept clean.

Although the squirrel-cage fan is rather expensive, its light weight, compactness, high efficiency, and quietness in operation make it particularly suitable for installation

in low-volume orchard sprayers. But this fan, like other centrifugal fans, is best suited for use on single-side sprayers. For best performance on double-side sprayers two fans should be used, one turning clockwise and the other counterclockwise.

The Air Vent

The design of the air vent is as important as the selection of the fan. For most efficient spray distribution the airstream should be linear, not turbulent, and the air velocity should be uniform at all positions in the air vent.

In the manufacture of air-blast sprayers, both high-volume and low-volume, it has been customary to make the cross section of the air vent uniform from top to bottom. The weakness of such a design is that much of the outgoing air is wasted. Little air is needed directly above the sprayer whereas, in mature plantings, a great deal of air is needed at the angle that takes in the top center of the tree. It is in the top center of large trees that air-blast sprayers are likely to be found wanting.

The most efficient air vents are narrower at the top and bottom than in the center (Figure 1). For the air velocity to be uniform from top to bottom of such an air vent, a static pressure of seven to nine inches of water is required within the blower housing. This means that the air-vent area must be considerably less than the air-inlet area. Not all types of fan develop the necessary static pressure.

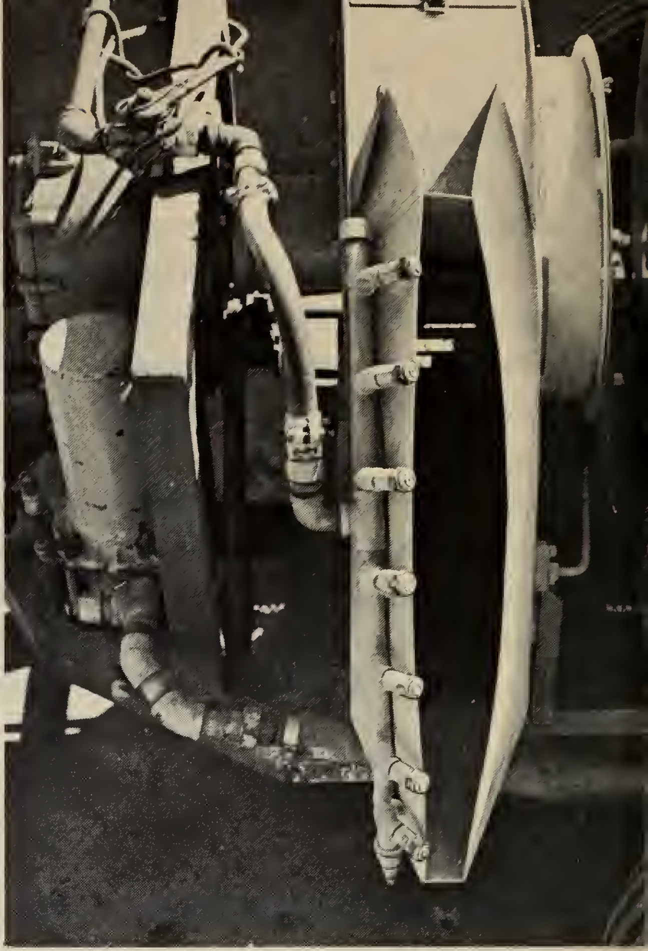

Figure 1 – An efficient air vent. Note that the center is wider than the top and bottom.

The Pump

Originally it was recommended that a pump pressure of at least 300 pounds per square inch be used in low-volume spraying with hollow-cone swirl nozzles. This required the use of a rather expensive piston pump. The use of such high pressure caused excessive wear on pump and pressure regulator parts and on the nozzle orifice discs and swirl plates.

Further research showed that a pressure of 100 pounds per square inch is sufficient for use with hollow-cone swirl nozzles having swirl plates with two passageways not more than 1/16 inch in diameter. Use of the lower pressure causes much less wear on pump, regulator and nozzle parts. It also makes it possible to use an alternative pump, the diaphragm type. The diaphragm pump is simple and rugged; it resists the abrasive action of concentrated wettable powders better than any other type of pump; it is easily and cheaply repaired; and it is inexpensive (7). Models are available that have satisfactory pressure and volume characteristics for low-volume spraying.

The Nozzle Manifold

The nozzles must be so spaced on the manifold that the spray cones formed by adjacent nozzles intersect within a few inches of the manifold. They must be placed in a wide-enough arc that the trees are enveloped in the spray. The number of nozzles required is usually five to seven per side. If fewer nozzle positions are provided it is often difficult to make a suitable nozzle selection for the outputs desired.

For large trees it is essential to introduce more spray liquid into the airstream in the wide, center portion (Figure 1) than in the portions above or below it. About two thirds of the spray should be emitted from the upper half of the manifold. Large nozzle orifices in the lower part of the manifold result in excessive spray deposits in the lower parts of the trees.

Tables to assist growers in selecting nozzles for a particular job are given in the manual "Operation and Maintenance of Air-blast Orchard Sprayers," a publication (6) of the Engineering Section of the Research Station. Every fruit grower who operates an air-blast sprayer should have a copy of this manual. It is available from offices of the British Columbia Department of Agriculture, or from the Research Station at Summerland.

Position of Nozzle Manifold

If the nozzles are mounted inside the air vent they may cause turbulence that will reduce the ability of the airstream to carry the spray through the tree. Therefore it is recommended that the nozzles be mounted outside the air vent, with the spray directed into the airstream at a forward angle of about 45 degrees.

The Spray Nozzles

The Research Station recommends hollow-cone swirl nozzles (Figure 2) for low-volume spraying. It also recommends wettable powders of pesticides as they are less likely to cause spray injury than liquid formulations. But when applied as spray

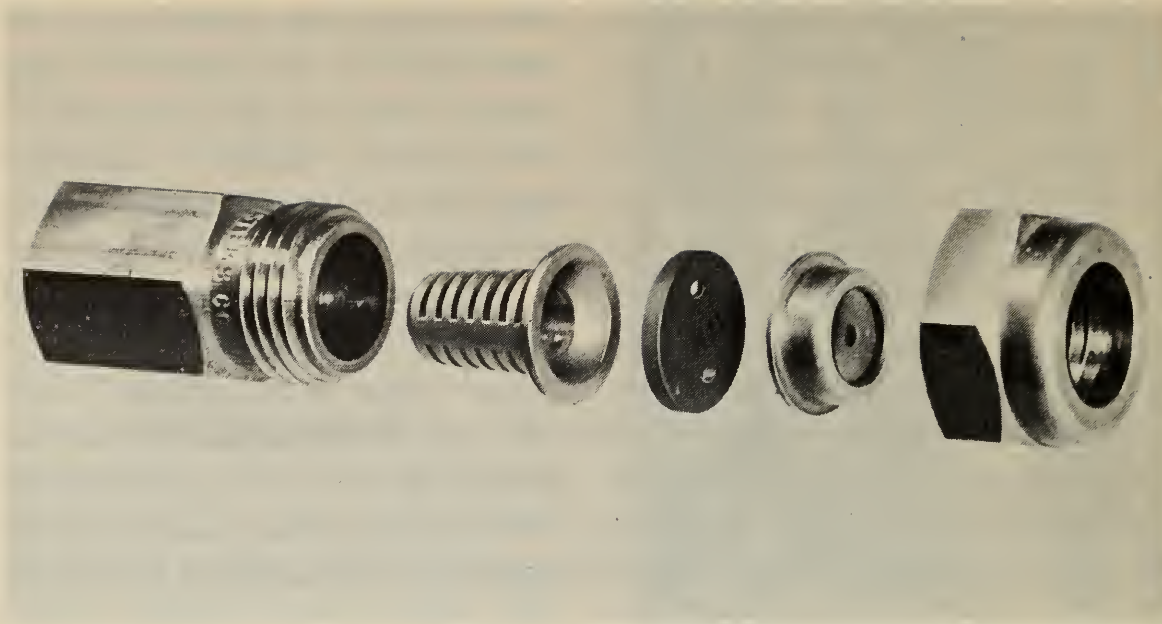

Figure 2 – Parts of a hollow-cone swirl nozzle. Left to right: body, strainer, swirl plate, orifice disc and swirl chamber, cap.

concentrates at 50 imperial gallons per acre, at pressures of 100 or more pounds per square inch, wettable powders may be very abrasive to spray nozzles. The orifice disc and swirl plate of the hollow-cone nozzle are particularly subject to abrasion.

Several years ago the Summerland studies showed that sintered tungsten carbide was the most abrasion-resistant material available for nozzle parts (2). Nowadays the best low-volume orchard sprayers on the British Columbia market are fitted with swirl plates and orifice discs of that material.

As far as spray breakup is concerned, the most important dimension of a swirl nozzle is the size of the passageways in the swirl plate. The larger the passageways the poorer is the spray breakup. For low-volume spraying, at pressures between 100 and 200 pounds per inch, each swirl plate should have two passageways not greater than 1/16 inch in diameter. The passageways should make an angle of about 45 degrees with the face of the plate.

The Spray Tank

Certain types of wood, e.g., teak, are satisfactory for sprayer tanks. The chief advantage of wood is that it does not corrode when in contact with acid or alkaline spray mixtures. In recent years, wooden tanks have generally fallen into disfavor in this country because of the difficulty of keeping them watertight. The preferred

material is stainless steel. Fiberglass-reinforced plastic has also been used with good success. Mild-steel tanks coated internally with an epoxy resin are cheaper than stainless steel or fiberglass and are satisfactory. However, epoxy coating may eventually scale off and cause trouble. A British low-volume sprayer, marketed in this province, has a hot-dipped galvanized tank that has proved satisfactory in England.

To facilitate agitation and draining, the spray tank should have a rounded or sloping bottom. To make it possible to pump right to the bottom of the tank there should be a suction well in the tank bottom, near the center (Figure 3), from which the suction line is fed. This well should be about two inches deep and should have an area of about 30 square inches.

Agitation of Spray Liquid

In low-volume spraying, good agitation is necessary to keep the heavy concentrations of wettable powders in uniform suspension from top to bottom of the spray tank. Agitation may be either mechanical or hydraulic.

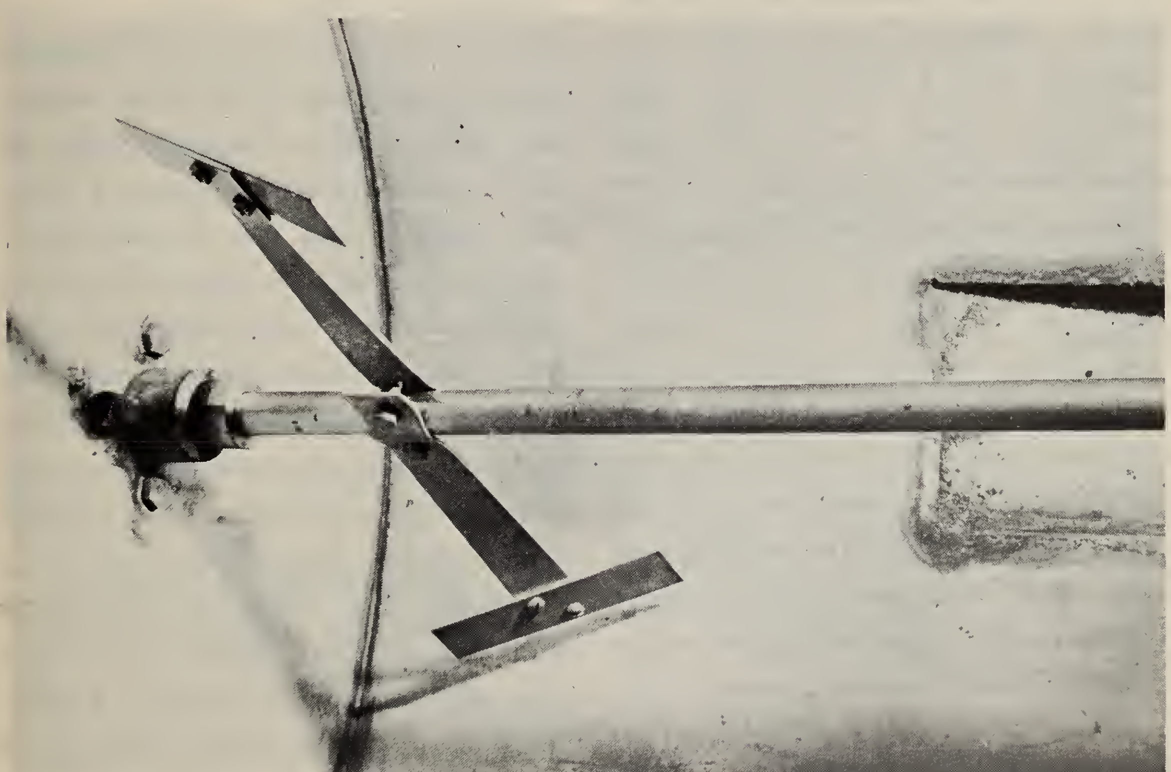

Figure 3 – Agitator paddles and suction well in properly designed sprayer. Looking down through the tank hatch.

For mechanical agitation, T-shaped paddles (Figure 3) are the best. The size and number of paddles must be properly related to speed of rotation and size of tank. There should be pronounced movement of the spray liquid when the tank is full. The speed of rotation should not be so high as to cause excessive beating when the level of the spray liquid falls to the agitator paddles. A speed of about 100 r.p.m. is recommended.

In hydraulic agitation the pump forces the spray liquid through nozzles in the bottom of the tank, and so keeps the contents in motion. Hydraulic agitation, though less expensive to install than mechanical agitation, is only effective if the nozzles are properly placed and if the pump circulates about one gallon per minute for each 10 gallons of spray liquid in the tank, while the sprayer is in operation.

Strainers

A low-volume sprayer of the type suggested by the Research Station may have five to seven nozzles per side, all of which have swirl plates with two openings 1/16 inch in diameter. Blockage may occur either in the swirl-plate openings or in the nozzle orifice. To avoid this annoying condition, several precautions are advisable. The spray tank should have a good strainer in the top opening to remove foreign matter from the water as the tank is being filled. The suction line to the pump should have an efficient and easily accessible strainer. The pressure line from the pump should have a fine strainer (blowout type) so that it may be quickly cleared of obstruction by opening a valve. Also, the strainer should be readily accessible. As a final safeguard against blockage, each nozzle should be fitted with a removable strainer.

ONE-SIDE AND TWO-SIDE SPRAYERS

In all orchard operations it is important to hold capital cost as low as is consistent with efficient production. When deciding whether to buy a one-side or a two-side sprayer, you must take into account the difference in capital cost, the difference in time required to spray the orchard, and also the ability of the sprayer to spray the orchard quickly enough when timing is critical. The machine should spray the orchard in not more than three days.

In general, for spraying orchards of up to 30 acres the additional cost of owning a two-side sprayer is not justified. The difference in original cost between a two-side and a one-side sprayer is usually about $1,600. This means an interest charge of about $96 per year and a depreciation charge of about $160 per year, or a total of $256 per year.

Now let us consider how much

time you can save by using the two-side sprayer. With a one-side machine you can spray 30 acres of mature apple trees in two or three days; with a two-side machine you can do it in about half the time. In most fruit districts of British Columbia about six sprays a year are necessary. Thus, to spray a 30-acre orchard with a one-side machine takes you only seven or eight days more per year than with a two-side machine. To save this seven or eight days of spraying time involves additional machine costs of $256 per year. You must decide whether this cost is justified by the time saved. When these fixed charges have to be borne by a 10- or 20-acre orchard the penalty imposed by the two-side machine is still heavier. On the other hand, in orchards of 40 acres or more the larger investment is justified.

If you have large blocks of closely spaced dwarf and semidwarf trees the situation is different. Then you may be justified in purchasing a two-side machine even though you are spraying considerably less than 30 acres.

ENGINE-EQUIPPED AND P.T.O.-DRIVEN SPRAYERS

The trend in the British Columbia fruit industry has shifted to sprayers with power-take-off drive; and it is a logical trend. Most of the orchard tractors bought in the last few years have the engine and the gear ratios required to power a rotary tiller. A one-side low-volume sprayer needs much the same tractor characteristics. The engine of an orchard tractor operates more efficiently under normal load than when idling. If the tractor has the required horsepower, the engine is not taxed when powering a low-volume sprayer.

The tractor must be so geared that it can maintain ground speeds between one and two miles per hour at a power-take-off speed of about 600 revolutions per minute. To do so, the older tractors must be fitted with a special underdrive; most of the newer tractors have suitable gearing.

A single-side power-take-off sprayer can be operated satisfactorily by a 25-horsepower tractor, and a double-side sprayer by a 40-horsepower tractor.

An engine-equipped sprayer costs considerably more than one with power-take-off drive, and has the added disadvantage of requiring engine maintenance. Its most evident advantage is that the blower operates independently of the tractor engine. So the air speed of the sprayer can be maintained without thought of the revolutions per minute of the tractor engine, or of the speed of travel.

SPEED OF TRAVEL

The speed at which a low-volume sprayer should be hauled depends on several factors. Velocity, volume,

and type of airstream (linear flow or turbulent), size of trees, distance between rows of trees, type of pruning, and density of foliage all have a bearing on performance (5).

In an orchard with trees up to 18 feet high, and 30 to 35 feet in diameter, an efficient low-volume sprayer may be hauled at one to two miles per hour. Dormant, prepink, and pink-spray applications may be undertaken at two miles per hour. When the trees are in full foliage the speed should be 1 to 1½ miles per hour, depending on the type of pruning. Open trees are more readily sprayed than trees with many branches and dense foliage. In closer plantings the speed of travel may be increased somewhat.

SURFACTANTS

In low-volume spraying the concentration of pesticide may be from three to 12 times as great as in high-volume spraying. At these concentrations there is obvious spray spotting of the fruit on the lower parts of the tree close to the sprayer vent when wettable powders are used. This is true even with a 50-gallon-per-acre output with no drip. Consumers nowadays have a growing awareness of spray residues, and

Figure 4 – Effect of a surfactant on the appearance of the spray deposit on fruit. Left: DDT, 6 pounds per acre, no surfactant. Right: DDT, 6 pounds per acre, surfactant added.

spray residues are suspect. It is best to offer fruit free from objectionable deposits whether they are toxic or not.

Spray spotting can be eliminated if liquid formulations are used. But most growers prefer to use wettable powders because, in low-volume spraying, they are less likely to injure the fruit or foliage. Spray spotting can be practically eliminated if the right kind of surface-active compound (surfactant) is added to a wettable powder spray mixture. The compound makes an otherwise visible spray residue almost invisible (Figure 4).

Since 1951 the Research Station has been studying how surfactants act in low-volume spraying. Eventually a particular type of surfactant was recommended: nonionic, low-foaming, and only slightly water-soluble (Triton B-1956 or Colloidal Spray Modifier). Experiments just concluded indicate that another (Nonidet P-40) may be suitable. It, too, should be used at ½ imperial pint per acre in 50 gallons of spray. With certain wettable powders, such as Guthion, Nonidet P-40 often foams excessively. To make it suitable for use with such materials, an anti-foaming agent may need to be added. With the use of wettable powders and the growing trend to a 50-gallon-per-acre output of spray, the use of a suitable surfactant will probably become common practice soon in the orchards of this province.

THE MARK II EXPERIMENTAL SPRAYER

Commercial low-volume spraying began in British Columbia in 1949, only a few months after the procedure had been officially approved. It was based on the performance of an experimental machine called the Okanagan Experimental Sprayer (3). At first the commercial low-volume sprayers were rather small and inexpensive. As the years went by they became larger and more expensive. The original idea was fading. The fruit grower was no longer able to buy a new sprayer that was small and low in price. A new approach was called for.

By 1958 most of the new orchard tractors were geared to operate at low speeds with normal engine revolutions. It was logical that they be used to power orchard sprayers. The Engineering Section of the Research Station then designed and built the Mark II Experimental Sprayer (Figure 5), a light, cheap successor to the original experimental machine. Unlike the original it was driven from the tractor power take-off (7).

The mark II machine was just as successful as its forerunner. Within a year it had become the prototype of several commercially built units. Since it represents a significant step in the development of low-volume orchard spraying, here is a brief description.

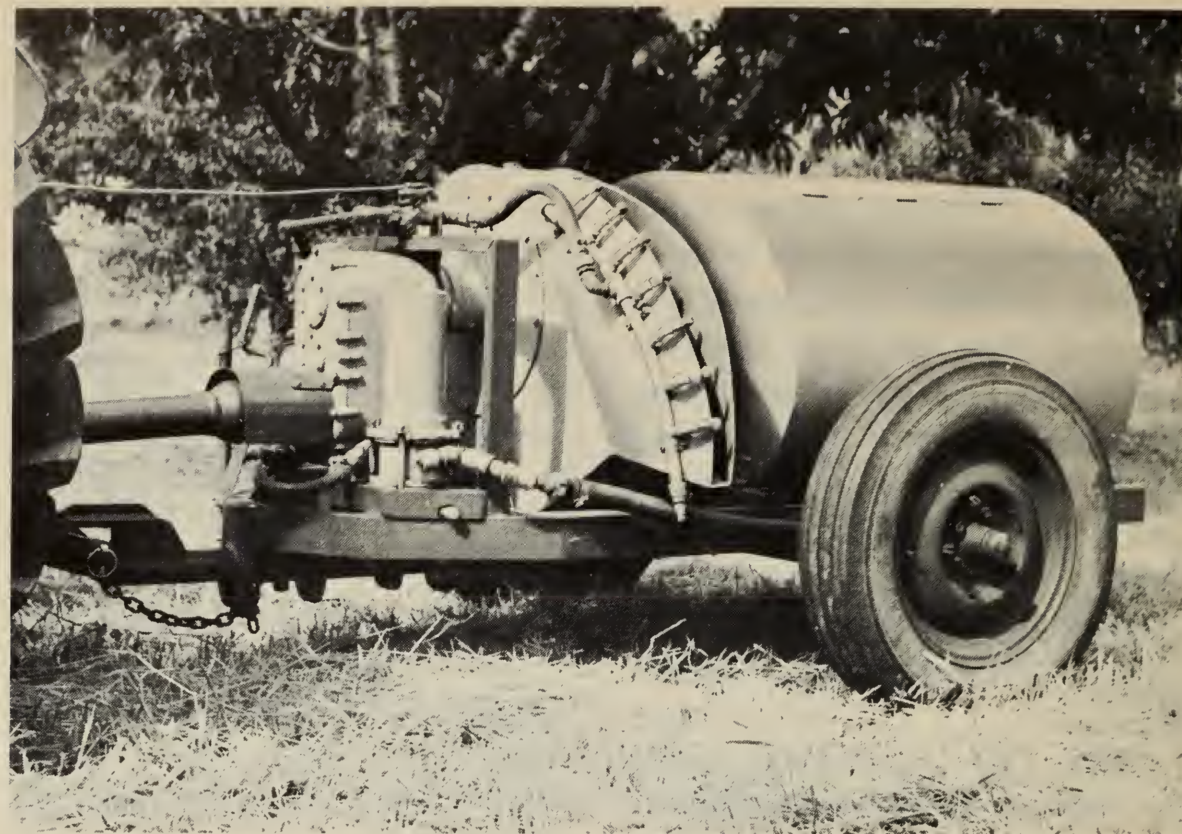

Figure 5 – Mark II Experimental Sprayer. This machine has served as a prototype for several low-cost, p.t.o.-driven commercial sprayers.

It is a small machine weighing only 800 pounds. Mounted on a low trailer, it is but 38 inches high. The 100-imperial-gallon, stainless-steel tank is oval in cross section. There is a suction well in the bottom of the tank, near the center. The power-take-off shaft from the tractor drives, through a gear box, the squirrel-cage blower, diaphragm pump, and T-paddle agitator. The air vent has a "keyhole" cross section (Figure 1). That part of the air vent with maximum air output is matched with maximum output of spray liquid from the largest orifices in the 7-nozzle manifold.

The hollow-cone swirl nozzles have tungsten carbide orifice discs and swirl plates. The nozzle manifold is mounted outside the air vent and the spray is directed into the airstream at a forward angle of 45 degrees. The suction line strainer, the pressure line strainer, and the drain valve of the spray tank are all readily accessible. The pressure gauge is mounted in front of the spray tank. Spray output is controlled by a quick-acting valve operated from the tractor seat.

An early difficulty with power-take-off sprayers was the danger of

breaking a universal of the power-take-off shaft on a sharp turn. In the Mark II the point at which the sprayer tongue is joined to the tractor drawbar is exactly halfway between the kunckles of the universal drive shaft. The tractor can make a maximum turn without binding of the universal because the angle of the turn is divided equally between the two joints. The suggestion for this arrangement came from the Instituut voor Tuinbouwtechniek, Wageningen, Holland. The tractor and sprayer can be turned safely in a 20-foot-diameter circle with the universal drive turning under full power.

PURCHASING A LOW-VOLUME SPRAYER

A low-volume sprayer should be purchased with care. If, to give an adequate deposit in the tops of the trees, a machine produces spray drip on the lower branches, it should not be considered. Nor should low price weigh heavily. Faulty pest control, or spray injury, or unsightly fruit, can soon outweigh a 10 percent or even a 20 percent difference in the cost of a sprayer.

You should not be misled by the appearance of the spray fog. If seen against a dark background a spray fog is more impressive than if seen against a light background. Also, the angle at which the sun's rays strike a spray fog has a marked effect on its apparent density. A poor machine applying 250 gallons per acre, or even 125 gallons, may seem much more impressive than a good machine applying 50 gallons. A two-side machine may be particularly deceptive. In one instance a small, one-side, high-velocity unit (130 m.p.h.) appeared to be doing an inferior job in a mature apple orchard. It was replaced by a large, two-side, low-velocity unit (85 m.p.h.). The two-side machine seemed distinctly the better. But chemical analyses showed that the small machine had, in fact, applied two to four times as much pesticide to the tree tops as the large one. With a minimum dosage, or with a pest difficult to control, that was a difference to cause trouble. Almost any low-volume machine can give adequate spray coverage in the lower branches of a large tree, but it takes a good one to give adequate coverage on branches that are 18 to 25 feet above ground.

When you buy a car you usually get just about what you pay for. When you buy a low-volume sprayer you may not be so fortunate. And a poor sprayer and poor crops often go hand in hand.

Before selecting a low-volume sprayer you should consult your district horticulturist concerning the characteristics of the various sprayers on the market.

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Some brand names are used in this publication because the chemical names are difficult for general use and there are no official common names for the active ingredients.

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1963

5M-30726-9:63

Cat. No. A53-1191

Copies of this publication may be obtained from:

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